52. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

PROCCEDINGS | 10 - 13 September 2007

FACULTY OF COMPUTER SCIENCE AND AUTOMATION

COMPUTER SCIENCE MEETS AUTOMATION

VOLUME I

Session 1 - Systems Engineering and Intelligent Systems

Session 2 - Advances in Control Theory and Control Engineering

Session 3 - Optimisation and Management of Complex Systems and Networked Systems

Session 4 - Intelligent Vehicles and Mobile Systems

Session 5 - Robotics and Motion Systems

TECHNISCHE UNIVERSITÄT ILMENAU

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbiografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.ddb.de** abrufbar.

ISBN 978-3-939473-17-6

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Kongressorganisation Andrea Schneider Tel.: +49 3677 69-2520 Fax: +49 3677 69-1743 e-mail: kongressorganisation@tu-ilmenau.de
Redaktionsschluss:	Juli 2007
Verlag:	Technische Universität Ilmenau/Universitätsbibliothek Universitätsverlag Ilmenau Postfach 10 05 65 98684 Ilmenau www.tu-ilmenau.de/universitaetsverlag
Herstellung und Auslieferung:	Verlagshaus Monsenstein und Vannerdat OHG Am Hawerkamp 31 48155 Münster www.mv-verlag.de
Layout Cover:	www.cey-x.de
Bezugsmöglichkeiten:	Universitätsbibliothek der TU Ilmenau Tel.: +49 3677 69-4615 Fax: +49 3677 69-4602

Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

Table of Contents

C O N T E N T S

Page

1 Systems Engineering and Intelligent Systems

A. Yu. Nedelina, W. Fengler 3
DIPLAN: Distributed Planner for Decision Support Systems

O. Sokolov, M. Wagenknecht, U. Gocht 9
Multiagent Intelligent Diagnostics of Arising Faults

V. Nissen 15
Management Applications of Fuzzy Conrol

O. G. Rudenko, A. A. Bessonov, P. Otto 21
A Method for Information Coding in CMAC Networks

Ye. Bodyanskiy, P. Otto, I. Pliss, N. Teslenko 27
Nonlinear process identification and modeling using general
regression neuro-fuzzy network

Ye. Bodyanskiy, Ye. Gorshkov, V. Kolodyazhniy , P. Otto 35
Evolving Network Based on Double Neo-Fuzzy Neurons

Ch. Wachten, Ch. Ament, C. Müller, H. Reinecke 41
Modeling of a Laser Tracker System with Galvanometer Scanner

K. Lüttkopf, M. Abel, B. Eylert 47
Statistics of the truck activity on German Motorways

K. Meissner, H. Hensel 53
A 3D process information display to visualize complex process
conditions in the process industry

F.-F. Steege, C. Martin, H.-M. Groß 59
Recent Advances in the Estimation of Pointing Poses on Monocular
Images for Human-Robot Interaction

A. González, H. Fernlund, J. Ekblad 65
After Action Review by Comparison – an Approach to Automatically
Evaluating Trainee Performance in Training Exercise

R. Suzuki, N. Fujiki, Y. Taru, N. Kobayashi, E. P. Hofer 71
Internal Model Control for Assistive Devices in Rehabilitation Technology

D. Sommer, M. Golz 77
Feature Reduction for Microsleep Detection

F. Müller, A. Wenzel, J. Wernstedt 83
A new strategy for on-line Monitoring and Competence Assignment to Driver and Vehicle

V. Borikov 89
Linear Parameter-Oriented Model of Microplasma Process in Electrolyte Solutions

A. Avshalumov, G. Filaretov 95
Detection and Analysis of Impulse Point Sequences on Correlated Disturbance Phone

H. Salzwedel 101
Complex Systems Design Automation in the Presence of Bounded and Statistical Uncertainties

G. J. Nalepa, I. Wojnicki 107
Filling the Semantic Gaps in Systems Engineering

R. Knauf 113
Compiling Experience into Knowledge

R. Knauf, S. Tsuruta, Y. Sakurai 119
Toward Knowledge Engineering with Didactic Knowledge

2 Advances in Control Theory and Control Engineering

U. Konigorski, A. López 129
Output Coupling by Dynamic Output Feedback

H. Toossian Shandiz, A. Hajipoor 135
Chaos in the Fractional Order Chua System and its Control

O. Katernoga, V. Popov, A. Potapovich, G. Davydau 141
Methods for Stability Analysis of Nonlinear Control Systems with Time Delay for Application in Automatic Devices

J. Zimmermann, O. Sawodny 145
Modelling and Control of a X-Y-Fine-Positioning Table

A. Winkler, J. Suchý 151
Position Based Force Control of an Industrial Manipulator

E. Arnold, J. Neupert, O. Sawodny, K. Schneider 157
Trajectory Tracking for Boom Cranes Based on Nonlinear Control and Optimal Trajectory Generation

K. Shaposhnikov, V. Astakhov 165
The method of ortogonal projections in problems of the stationary magnetic field computation

J. Naumenko 167
The computing of sinusoidal magnetic fields in presence of the surface with bounded conductivity

K. Bayramkulov, V. Astakhov 169
The method of the boundary equations in problems of computing static and stationary fields on the topological graph

T. Kochubey, V. Astakhov 171
The computation of magnetic field in the presence of ideal conductors using the Integral-differential equation of the first kind

M. Schneider, U. Lehmann, J. Krone, P. Langbein, Ch. Ament, P. Otto, U. Stark, J. Schrickel 173
Artificial neural network for product-accompanied analysis and control

I. Jawish 179
The Improvement of Traveling Responses of a Subway Train using Fuzzy Logic Techniques

Y. Gu, H. Su, J. Chu 185
An Approach for Transforming Nonlinear System Modeled by the Feedforward Neural Networks to Discrete Uncertain Linear System

3 Optimisation and Management of Complex Systems and Networked Systems

R. Franke, J. Doppelhammer 193
Advanced model based control in the Industrial IT System 800xA

H. Gerbracht, P. Li, W. Hong 199
An efficient optimization approach to optimal control of large-scale processes

T. N. Pham, B. Wutke 205
Modifying the Bellman's dynamic programming to the solution of the discrete multi-criteria optimization problem under fuzziness in long-term planning

S. Ritter, P. Bretschneider 211
Optimale Planung und Betriebsführung der Energieversorgung im liberalisierten Energiemarkt

P. Bretschneider, D. Westermann 217
Intelligente Energiesysteme: Chancen und Potentiale von IuK-Technologien

Z. Lu, Y. Zhong, Yu. Wu, J. Wu 223
WSReMS: A Novel WSDM-based System Resource Management Scheme

M. Heit, E. Jennenchen, V. Kruglyak, D. Westermann 229
Simulation des Strommarktes unter Verwendung von Petrinetzen

O. Sauer, M. Ebel 237
Engineering of production monitoring & control systems

C. Behn, K. Zimmermann 245
Biologically inspired Locomotion Systems and Adaptive Control

J. W. Vervoorst, T. Kopfstedt 251
Mission Planning for UAV Swarms

M. Kaufmann, G. Bretthauer 257
Development and composition of control logic networks for
distributed mechatronic systems in a heterogeneous architecture

T. Kopfstedt, J. W. Vervoorst 263
Formation Control for Groups of Mobile Robots Using a Hierarchical
Controller Structure

M. Abel, Th. Lohfelder 269
Simulation of the Communication Behaviour of the German Toll System

P. Hilgers, Ch. Ament 275
Control in Digital Sensor-Actuator-Networks

C. Saul, A. Mitschele-Thiel, A. Diab, M. Abd rabou Kalil 281
A Survey of MAC Protocols in Wireless Sensor Networks

T. Rossbach, M. Götze, A. Schreiber, M. Eifart, W. Kattanek 287
Wireless Sensor Networks at their Limits – Design Considerations
and Prototype Experiments

Y. Zhong, J. Ma 293
Ring Domain-Based Key Management in Wireless Sensor Network

V. Nissen 299
Automatic Forecast Model Selection in SAP Business Information
Warehouse under Noise Conditions

M. Kühn, F. Richter, H. Salzwedel 305
Process simulation for significant efficiency gains in clinical departments –
practical example of a cancer clinic

D. Westermann, M. Kratz, St. Kümmerling, P. Meyer 311
Architektur eines Simulators für Energie-, Informations- und Kommunikations-technologien

P. Moreno, D. Westermann, P. Müller, F. Büchner 317
Einsatzoptimierung von dezentralen netzgekoppelten Stromerzeugungs-anlagen (DEA) in Verteilnetzen durch Erhöhung des Automatisierungsgrades

M. Heit, S. Rozhenko, M. Kryvenka, D. Westermann 331
Mathematische Bewertung von Engpass-Situationen in Transportnetzen elektrischer Energie mittels lastflussbasierter Auktion

M. Lemmel, M. Schnatmeyer 339
RFID-Technology in Warehouse Logistics

V. Krugljak, M. Heit, D. Westermann 345
Approaches for modelling power market: A Comparison.

St. Kümmerling, N. Döring, A. Friedemann, M. Kratz, D. Westermann 351
Demand-Side-Management in Privathaushalten – Der eBox-Ansatz

4 Intelligent Vehicles and Mobile Systems

A. P. Aguiar, R. Ghabchelloo, A. Pascoal, C. Silvestre , F. Vanni 359
Coordinated Path following of Multiple Marine Vehicles: Theoretical Issues and Practical Constraints

R. Engel, J. Kalwa 365
Robust Relative Positioning of Multiple Underwater Vehicles

M. Jacobi, T. Pfützenreuter, T. Glotzbach, M. Schneider 371
A 3D Simulation and Visualisation Environment for Unmanned Vehicles in Underwater Scenarios

M. Schneider, M. Eichhorn, T. Glotzbach, P. Otto 377
A High-Level Simulator for heterogeneous marine vehicle teams under real constraints

A. Zangrilli, A. Picini 383
Unmanned Marine Vehicles working in cooperation: market trends and technological requirements

T. Glotzbach, P. Otto, M. Schneider, M. Marinov 389
A Concept for Team-Orientated Mission Planning and Formal Language Verification for Heterogeneous Unmanned Vehicles

M. A. Arredondo, A. Cormack 395
SeeTrack: Situation Awareness Tool for Heterogeneous Vehicles

J. C. Ferreira, P. B. Maia, A. Lucia, A. I. Zapaniotis 401
Virtual Prototyping of an Innovative Urban Vehicle

A. Wenzel, A. Gehr, T. Glotzbach, F. Müller 407
Superfour-in: An all-terrain wheelchair with monitoring possibilities to enhance the life quality of people with walking disability

Th. Krause, P. Protzel 413
Verteiltes, dynamisches Antriebssystem zur Steuerung eines Luftschiffes

T. Behrmann, M. Lemmel 419
Vehicle with pure electric hybrid energy storage system

Ch. Schröter, M. Höchemer, H.-M. Groß 425
A Particle Filter for the Dynamic Window Approach to Mobile Robot Control

M. Schenderlein, K. Debes, A. Koenig, H.-M. Groß 431
Appearance-based Visual Localisation in Outdoor Environments with an Omnidirectional Camera

G. Al Zeer, A. Nabout, B. Tibken 437
Hindernisvermeidung für Mobile Roboter mittels Ausweichecken

5 Robotics and Motion Systems

Ch. Schröter, H.-M. Groß 445
Efficient Gridmaps for SLAM with Rao-Blackwellized Particle Filters

St. Müller, A. Scheidig, A. Ober, H.-M. Groß 451
Making Mobile Robots Smarter by Probabilistic User Modeling and Tracking

A. Swerdlow, T. Machmer, K. Kroschel, A. Laubenheimer, S. Richter 457
Opto-acoustical Scene Analysis for a Humanoid Robot

A. Ahranovich, S. Karpovich, K. Zimmermann 463
Multicoordinate Positioning System Design and Simulation

A. Balkovoy, V. Cacenkin, G. Slivinskaia 469
Statical and dynamical accuracy of direct drive servo systems

Y. Litvinov, S. Karpovich, A. Ahranovich 477
The 6-DOF Spatial Parallel Mechanism Control System Computer Simulation

V. Lysenko, W. Mintchenya, K. Zimmermann 483
Minimization of the number of actuators in legged robots using
biological objects

J. Kroneis, T. Gastauer, S. Liu, B. Sauer 489
Flexible modeling and vibration analysis of a parallel robot with
numerical and analytical methods for the purpose of active vibration damping

A. Amthor, T. Hausotte, G. Jäger, P. Li 495
Friction Modeling on Nanometerscale and Experimental Verification

Paper submitted after copy deadline

2 Advances in Control Theory and Control Engineering

V. Piwek, B. Kuhfuss, S. Allers
Feed drivers – Synchronized Motion is leading to a process optimization 503

R. Güttler, A. Schneider, Ch. Ament, J. Schmitz
Using a reinforcement learning approach in a discrete event manufacturing system **nur online verfügbar/only on-line ones available**

52nd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
10 – 13 September 2007

R. Engel/ J. Kalwa

Robust Relative Positioning of Multiple Underwater Vehicles for the European GREX Project

INTRODUCTION: THE GREX PROJECT

The main goal of the European GREX project is to achieve a first level of distributed "intelligence" through dependable underwater vehicles that are interconnected and cooperate towards the coordinated execution of tasks. Thus the project will witness the development of theoretical methods and practical tools for multiple vehicle cooperation, bridging the gap between concept and practice. The technology developed must be on one hand sufficiently generic in order to interface pre-existing heterogeneous systems. On the other hand, it must be sufficiently robust to cover problems caused by faulty communications. In this paper, we consider one interesting navigation problem arising in GREX.

NAVIGATION OF MULTIPLE AUVS

The positioning problem for multiple underwater vehicles, seen from the viewpoints of coordinated control and from underwater communication, shows some new aspects compared to the single vehicle positioning problem. In principle, one can define the following two subproblems of the positioning problem for multiple underwater vehicles.

Absolute positioning. The task of determining the position of each individual vehicle in an earth fixed frame using navigation data of the distributed AUV sensor network.

Relative positioning. The task of determining the mutual relative positions of the members of the group, using navigation data of the distributed AUV sensor network. Usually these subproblems are not subdivided in such a rigid way. The reason for this is that in most of existing projects dealing with multiple AUVs, the usage of an acoustic positioning system, such as LBL or USBL is proposed, see e.g. [2] or [3]. Since these concepts allow the simultaneous tracking of multiple vehicles with bounded error, they can serve as a solution to both subproblems. However, the application of acoustic tracking systems impede large scale missions, call for large operational effort (in case of LBL) or make the presence of some surface vessel (in case of USBL) necessary.

We propose a method, by which relative positioning is possible by means of merely

- A dead reckoning navigation system on each vehicle of the group.
- A communication system which is able to distribute information in the AUV network (via acoustic modems).
- A device, to be implemented on each vehicle, which is capable of performing mutual range measurements (by the same modems).

Our general setting consists of a number N of underwater vehicles, each carrying a suite of sensors which enables the vehicle to operate by its own. The individual vehicles may be equipped with navigation systems of very diverse qualities. The state of the art for AUV navigation systems use an inertial navigation unit and several aiding sensors. By carefully fusing the sensor data, exhibiting partial redundancy of the navigation sensors, very accurate results can be achieved, even for the dead reckoning case without any absolute aiding of the position (see e.g. [6], [8]). The navigation accuracy achieved by AUVs range from some few meters per hour (for high performance INS/DVL combinations for site surveys) down to more than hundred meters per hour (for low cost compass/velocity sensor combinations) for site surveys.

OPERATIONAL SETUP

We assume that each individual navigation system is initialized independently, normally by means of a GPS fix after launch, while still remaining at the surface. Each member vehicle of the swarm will be equipped with an acoustic modem and a computer, on which the team functionalities are implemented. These functionalities consist in modules for team mission handling, coordinated control, communication managmement and team navigation, see fig. 1.

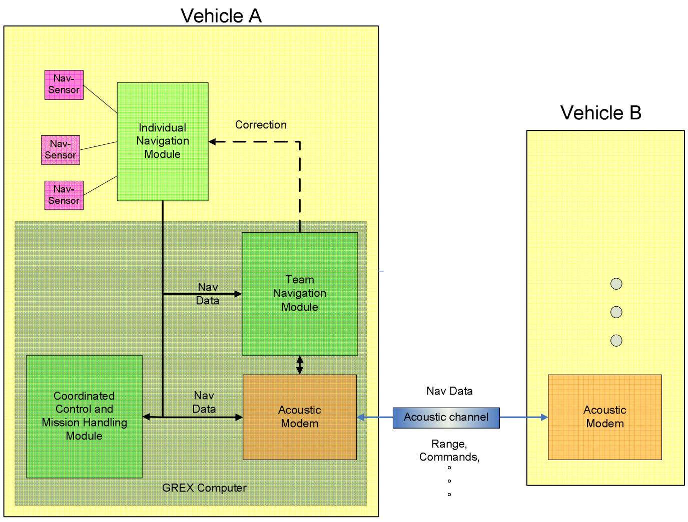

Figure 1: Vehicle specific hard- and software

The GREX navigation module receives input data from the proprietary navigation system of the respective vehicle on the one hand and from the communication module on the other hand, implementing the interface to other member vehicles. In particular, we make no special assumptions about the network topology, protocols, etc. We will merely assume that the GREX navigation module on vehicle A receives from time to time data from some other vehicle, say B. The origin of a data set will always be known to vehicle A via an ID contained in the header of the received data. The method for relative positioning, proposed here, only processes data originating from different vehicles independently. Thus, we can restrict ourselves to the special case of only two vehicles exchanging data. In the case of N vehicles, each navigation module runs N-1 instances of the algorithm described below, independently.

BASIC PRINCIPLE

Without an absolute position aiding, the individual position errors will show some drift behaviour, due to uncompensated errors in the dead reckoning navigation systems of the vehicle navigation systems. The respective position estimates can hence not be used directly for coordinated control purposes because of the growth of the relative position error over time. As a consequence, the information available to each vehicle has to be enhanced. According to the philosophy of the GREX project, any arbitrary AUV should be integrable (and, as well, removable) into (from) the group with comparably low extra cost. The least demanding type of additional measurements for relative position aiding, from a hardware point of view, consists in the determination of ranges between vehicles. Many acoustic modems on the market are capable to do range measurements when establishing a connection between two stations. This is done by measuring round trip time of flight of a pulse signal, emitted by one and received by a second modem which in turn retransmits the pulse signal. The draw-back of this method is that one vehicle can exchange range data with not more than one other modem at the same time.

The basic concept for the solution of the relative positioning problem is illustrated in fig. 2 for the two dimensional case. It is based on the idea that a set of distances can be generated from the real measurements which geometrically determine the relative position of vehicle B to vehicle A uniquely by trilateration. In view of fig. 2, these distances are the range observations of three consecutive modem connections, r_1^{AB}, r_2^{AB}, r_3^{AB}, the position differences Δp_{12}^{A}, Δp_{12}^{A} for vehicle A and the position differences for vehicle B Δp_{12}^{B}, Δp_{12}^{B}, all of them taken between consecutive time instances of a connection between A and B. The crucial point here is that, although the individual position estimates of the the dead reckoning navigation systems of A and B are subject to drift, the difference quantities will be in general quite accurate, depending on the quality of the dead reckoning sensors and on the time span related to the position differences. The method is in some sense a generalization of the Synthetic Long Baseline concept, introduced in [9].

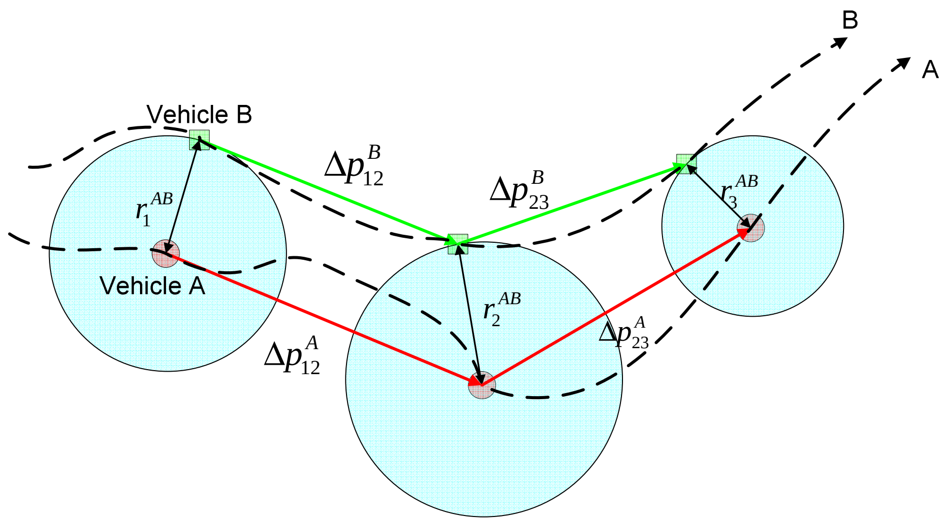

Figure 2: Consecutive range and position difference observations for two vehicles.

For a practical implementation, we will avoid solving the associated trilateration problem directly by a algebraic or numeric algorithm. The main reason is, that an “exact” solution might show large sensitivity with respect to the input data. A second reason is the need to explicitly consider error characteristics of the measurements. Therefore, an extended Kalman filter solution is adopted here (see e.g. [5] for a standard reference). We will refer to this construction as a Relative Position Kalman Filter (RPKF) in the sequel.

SIMULATION RESULTS

For sake of clarity of presentation we will discuss a comparably simple case. Only two vehicles are considered, executing a coordinated turn manoeuvre, see fig. 3. These trajectories were occupied with a (quite large) random walk of $30\,\mathrm{m}/\sqrt{\mathrm{hour}}$, yielding the assumed trajectories as computed by the respective dead reckoning navigation system of the two vehicles. The data connection rate was chosen to be 60s, determining the rate of range observations. Position updates were assumed to be received by A from B every 15 s. The EKF time increment is chosen as $T_{tu} = 1\,\mathrm{sec}$.

Fig. 4 shows estimated positions of vehicle B. The green trajectory indicates the estimate of B's own dead reackoning navigation about four minutes after mission start. The red line represents the estimate for B's position, given from A's point of view, using the result of the RPKF running on A . For displaying the results, A's own navigation was supposed to be perfect. As can be deduced from fig. 4, the RPKF solution appears to converge to the real vehicle trajectory. Remember that this will not hold in reality for the absolute positions, displayed here.

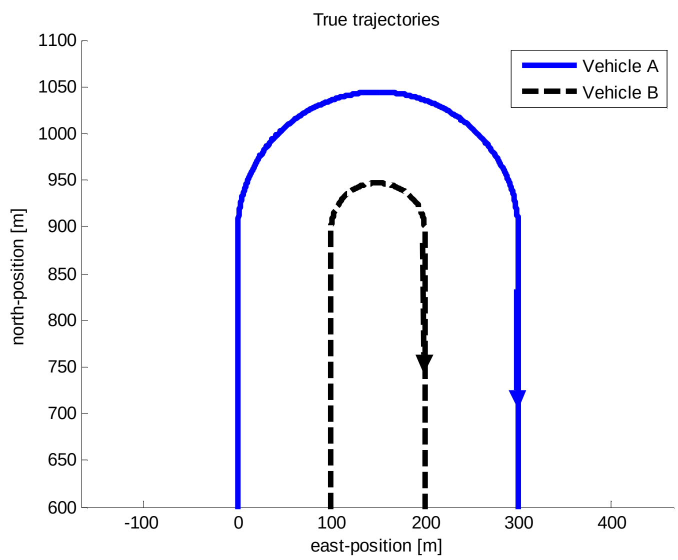

Figure 3: True trajectories of simulated vehicles

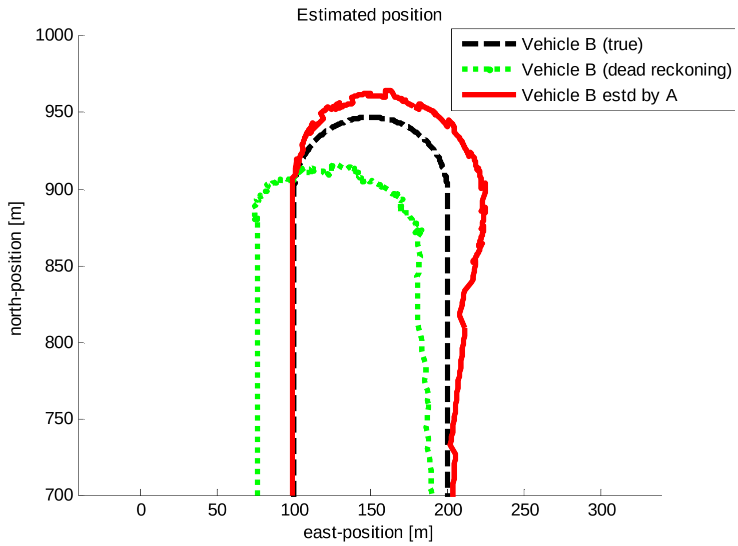

Figure 4: Relative position of B, estimated by own dead reckoning (green dotted) and by A's RPKF (red cont).

CONCLUSIONS

A method was presented, allowing the determination of relative positions of underwater vehicles in a coordinated group, using only range observations and the dead reckoning estimates of the individual vehicles. The method is based on the basic idea of a trilateration, intersecting certain spheres, which are determined by the relative motion of the vehicles.

Refernces:

[1] Bar-Shalom, Y, and Li, XR (1995). *Multitarget-Multisensor Tracking – Principles and Techniques.* Lecure Notes, Univ Connecticut.
[2] Cruz, N, Matos N, Borges de Sousa, J, Pereira, FL, Silvay, J, Silvay, E, Coimbraz, J, and Brogueira Dias, J (2003). "Operations with Multiple Autonomous Underwater Vehicles: the PISCIS Project". *2nd ann. Symp. Autonomous Intelligent Networks and Systems.*
[3] Cuff, TR, and Wall, RW, "Support Platform and Communications to manage Cooperative AUV Operations". *www.ee.uidaho.edu/ee/digital/rwall/*
[4] Durrant-Whyte, H., and Bayley, T. (2006). "Simultaneous Localization and Mapping: Part I". *IEEE Robotics & Automation Magazine, June 2006.*
[5] Gelb, A (1994). *Applied Optimal Estimation.* MIT Press.
[6] Grenon, G, An, PE, Smith, SM, and Healey, AJ (2001). "Enhancement of the Inertial Navigation System for the Morpheus Autonomous Underwater Vehicles". *IEEE J Oceanic Eng*, Vol 26, N0 4, pp 548-560.
[7] www.GREX-project.eu
[8] Larsen, MB (2000a). "High Performance Doppler-Inertial Navigation – Experimental Results". Proc IEEE OCEANS 2000.
[9] Larsen, MB (2000). "Synthetic Long Baseline Navigation of Underwater Vehicles", *Proc IEEE Oceans Conf.*

Authors:
Dr.-Ing. Robert Engel
Dipl.-Ing. Jörg Kalwa
ATLAS ELEKTRONIK GmbH, Sebaldsbrücker Heerstraße 235
28309, Bremen
Phone: +49 421 457 2853
Fax: +49 421 457 2020
E-mail: robert.engel@atlas-elektronik.com, joerg.kalwa@atlas-elektronik.com